

Claims

- [c1] 1.A method for cleaning internal channels in an article, said method comprising:
providing an article, said article comprising at least one internal channel
comprising at least one inlet port and at least one outlet port;
providing a cleaning apparatus, said apparatus comprising
a cleaning fluid,
a reservoir containing said cleaning fluid, said reservoir comprising an interface
adapted to accommodate attachment of said reservoir to said article, said
interface comprising an orifice to allow fluid communication between said
reservoir and said at least one internal channel of said article,
a transmitter of vibrational energy projecting into said reservoir, said
transmitter comprising a transmitter tip, and
a source of vibrational energy coupled to said transmitter, said vibrational
energy comprising a frequency and a wavelength; and
attaching said article to said apparatus at said interface.
- [c2] 2.The method of claim 1, further comprising transmitting vibrational energy
from said source of vibrational energy through said transmitter to said article.
- [c3] 3. The method of claim 2, wherein transmitting comprises transmitting
vibrational energy wherein said frequency is at least about 100 Hz.
- [c4] 4.The method of claim 3, wherein said frequency is at least about 10 kHz.
- [c5] 5.The method of claim 2, wherein said source of vibrational energy is tunable.
- [c6] 6.The method of claim 2, further comprising adjusting at least one of
a. an energy transmission distance extending from said transmitter tip to a
desired reference point on said article, and
b. said frequency of said vibrational energy,
according to the equation $d = n \lambda / 4$, where d is said energy transmission
distance, λ is said wavelength, and $n = 1, 3, 5, 7, 9, \dots$
- [c7] 7.The method of claim 1, wherein said reservoir further comprises a cleaning
fluid inlet connected to a source of said cleaning fluid, and a cleaning fluid
outlet to expel excess cleaning fluid, and wherein said method further

comprises flowing said cleaning fluid from said fluid source through said reservoir and said at least one internal channel of said article, and out through said cleaning fluid outlet.

[c8] 8.The method of claim 7, wherein said interface further comprises a manifold in fluid communication with said at least one internal channel of said article, and wherein flowing further comprises flowing said cleaning fluid through said manifold to direct said fluid into said at least one inlet port of said at least one internal channel and out of said at least one exit port of said at least one internal channel.

[c9] 9.The method of claim 1, wherein providing said article comprises providing a gas turbine engine component, said component comprising at least one internal channel, said at least one internal channel comprising at least one inlet port and at least one outlet port.

[c10] 10.The method of claim 9, wherein said component comprises a turbine blade.

[c11] 11.The method of claim 1, wherein said cleaning fluid comprises a liquid.

[c12] 12.The method of claim 11, wherein said fluid comprises water.

[c13] 13.The method of claim 11, wherein said fluid further comprises a surfactant.

[c14] 14.The method of claim 11, wherein said liquid comprises at least one of an acid and a base.

[c15] 15.The method of claim 2, wherein said fluid further comprises abrasive solid particles.

[c16] 16.The method of claim 7, wherein providing said cleaning apparatus further comprises providing a fluid circulator coupled to said cleaning fluid outlet and said source of cleaning fluid, and wherein flowing comprises circulating said cleaning fluid.

[c17] 17.The method of claim 1, wherein said transmitter of said apparatus comprises a probe.

[c18] 18.The method of claim 1, wherein said transmitter of said apparatus comprises a horn.

[c19] 19.The method of claim 1, wherein said reservoir of said apparatus comprises a material that is substantially inert to said cleaning fluid.

[c20] 20.The method of claim 19, wherein said material comprises polytetrafluoroethylene.

[c21] 21.A method for cleaning internal channels of a gas turbine engine component, comprising:
providing a gas turbine engine component, said component comprising at least one internal channel, said at least one internal channel comprising at least one inlet port and at least one exit port;
providing a cleaning apparatus, said apparatus comprising
a. a cleaning fluid comprising a liquid;
b. a reservoir containing said fluid, said reservoir comprising
i. an interface adapted to accommodate attachment of said reservoir to said gas turbine engine component, said interface comprising a manifold adapted to allow fluid communication between said reservoir and said at least one internal channel of said engine component,
ii. a cleaning fluid inlet connected to a source of said cleaning fluid, and
iii. a cleaning fluid outlet,
c. a transmitter of vibrational energy projecting into said reservoir, said transmitter comprising a transmitter tip; and
d. a source of vibrational energy coupled to said transmitter, said vibrational energy comprising a frequency and a wavelength;
attaching said engine component to said apparatus at said interface;
transmitting vibrational energy from said source of vibrational energy through said transmitter to said article;
adjusting an energy transmission distance extending from said transmitter tip to a desired reference point on said article according to the equation $d = n \lambda / 4$, where d is said energy transmission distance, λ is said wavelength, and $n = 1, 3, 5, 7, 9, \dots$ and

flowing said cleaning fluid from said fluid source through said reservoir and said at least one internal channel of said article, and out through said cleaning fluid outlet.

[c22] 22. An apparatus for cleaning internal channels in an article, said apparatus comprising:
a cleaning fluid;
a reservoir containing said cleaning fluid, said reservoir comprising an interface adapted to accommodate attachment of said reservoir to an article comprising at least one internal channel, said at least one channel comprising at least one inlet port and at least one exit port, said interface comprising an orifice to allow fluid communication between said reservoir and said at least one internal channel of said article;
a transmitter of vibrational energy adjustably projecting into said reservoir; and
a source of vibrational energy coupled to said transmitter, said vibrational energy comprising a frequency and a wavelength.

[c23] 23. The apparatus of claim 22, wherein said fluid comprises a liquid.

[c24] 24. The apparatus of claim 23, wherein said fluid comprises water.

[c25] 25. The apparatus of claim 23, wherein said fluid further comprises a surfactant.

[c26] 26. The apparatus of claim 23, wherein said liquid comprises at least one of an acid and a base.

[c27] 27. The apparatus of claim 23, wherein said fluid further comprises abrasive solid particles.

[c28] 28. The apparatus of claim 22, wherein said reservoir further comprises:
a cleaning fluid inlet connected to a source of said cleaning fluid; and
a cleaning fluid outlet.

[c29] 29. The apparatus of claim 28, further comprising a fluid circulator coupled to said source of said cleaning fluid.

[c30] 30. The apparatus of claim 29, wherein said circulator comprises a pump.

[c31] 31.The apparatus of claim 22, wherein said interface further comprises a manifold to direct said fluid into said at least one inlet port of said at least one internal channel and out of said at least one exit port of said at least one internal channel.

[c32] 32.The apparatus of claim 22, wherein said frequency is at least about 100 Hz.

[c33] 33.The apparatus of claim 32, wherein said frequency is at least 10 kHz.

[c34] 34.The apparatus of claim 22, wherein said source of vibrational energy is tunable.

[c35] 35.The apparatus of claim 22, wherein said transmitter comprises a probe.

[c36] 36.The apparatus of claim 22, wherein said transmitter comprises a horn.

[c37] 37.The apparatus of claim 22, wherein said cavity comprises a material that is substantially inert to said cleaning fluid.

[c38] 38.The apparatus of claim 37, wherein said material is polytetrafluoroethylene.

[c39] 39.The apparatus of claim 22, wherein said interface is adapted to accommodate attachment of said reservoir to at least one gas turbine engine component, said at least one component comprising at least one internal channel.

[c40] 40.The apparatus of claim 39, wherein said at least one gas turbine engine component is a turbine blade.

[c41] 41.An apparatus for cleaning internal channels of a gas turbine engine component, said apparatus comprising:
a cleaning fluid comprising water;
a reservoir containing said water, said reservoir comprising
an interface adapted to accommodate attachment of said reservoir to a gas turbine engine component comprising at least one internal channel, said interface comprising an orifice to allow fluid communication between said reservoir and said at least one internal channel of said engine component,
a cleaning fluid inlet connected to a source of said cleaning fluid, and

a cleaning fluid outlet to expel excess cleaning fluid;
a fluid circulator coupled to said source of said cleaning fluid;
a transmitter of vibrational energy projecting into said reservoir, said transmitter comprising a transmitter tip; and
a source of vibrational energy coupled to said transmitter, said vibrational energy comprising a frequency and a wavelength;
wherein said transmitter is adjustably projecting into said reservoir to define an energy transmission distance, said energy transmission distance extending from said transmitter tip to a desired reference point on said article, and said energy transmission distance is related to said wavelength of said vibrational energy through the equation

$$d = n \lambda / 4;$$

where d is said energy transmission distance, λ is said wavelength, and $n = 1, 3, 5, 7, 9, \dots$.